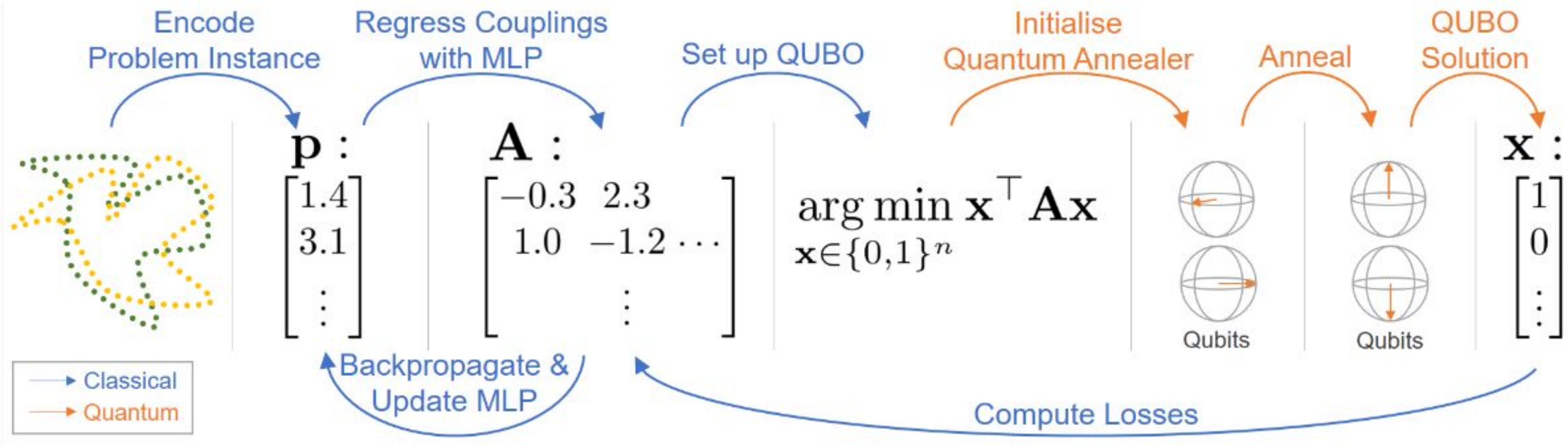
Quantum Computing Meeting

28.06.2023+2weeks

QuAnt: Learned coulings for QUBO problems



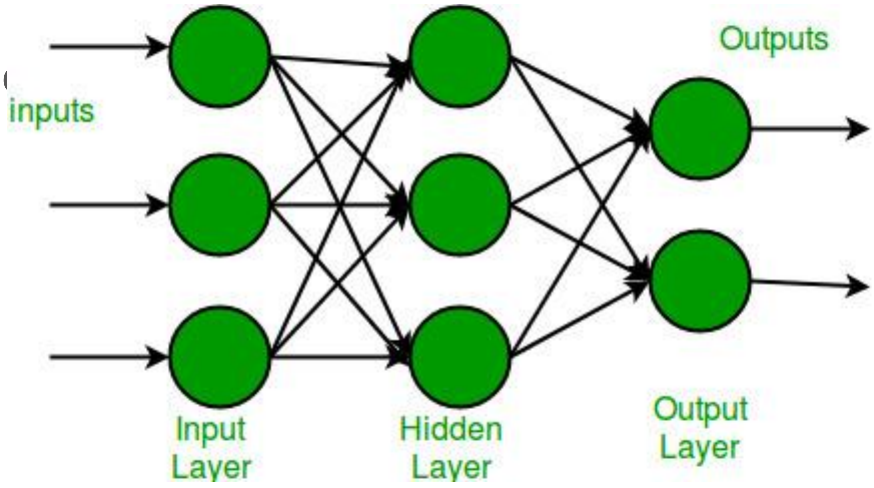
learn QUBO forms from data for any problem type using the backpropagation

The paper introduces a contrastive loss that circumvents the non-differentiable nature of quantum annealing/simulated annealing

Competitive performance to derived QUBO, resistance to noise

Multi-layered perceptron

- Fully connected neural network (every node is connected w every neuron in the next layer)
- Very simple “starting” NN
- Loss gradient is calculated one layer at a time, moving from the output to input layer →loss function has to be differentiable
- However (!) this has fixed input and outputs



Loss function

General loss differentiable w respect to A:

$$L_{\text{gap}} = \hat{\mathbf{x}}^\top \mathbf{A} \hat{\mathbf{x}} - \mathbf{x}^{*\top} \mathbf{A} \mathbf{x}^*$$

Ground truth solution

$$\frac{\partial L_{\text{gap}}(\mathbf{A})}{\partial \mathbf{A}_{i,j}} = 2\hat{\mathbf{x}}_i\hat{\mathbf{x}}_j - 2\mathbf{x}_i^*\mathbf{x}_j^* - 2\frac{\partial \mathbf{x}^*(\mathbf{A})}{\partial \mathbf{A}_{i,j}}\mathbf{A}\mathbf{x}^*,$$

0

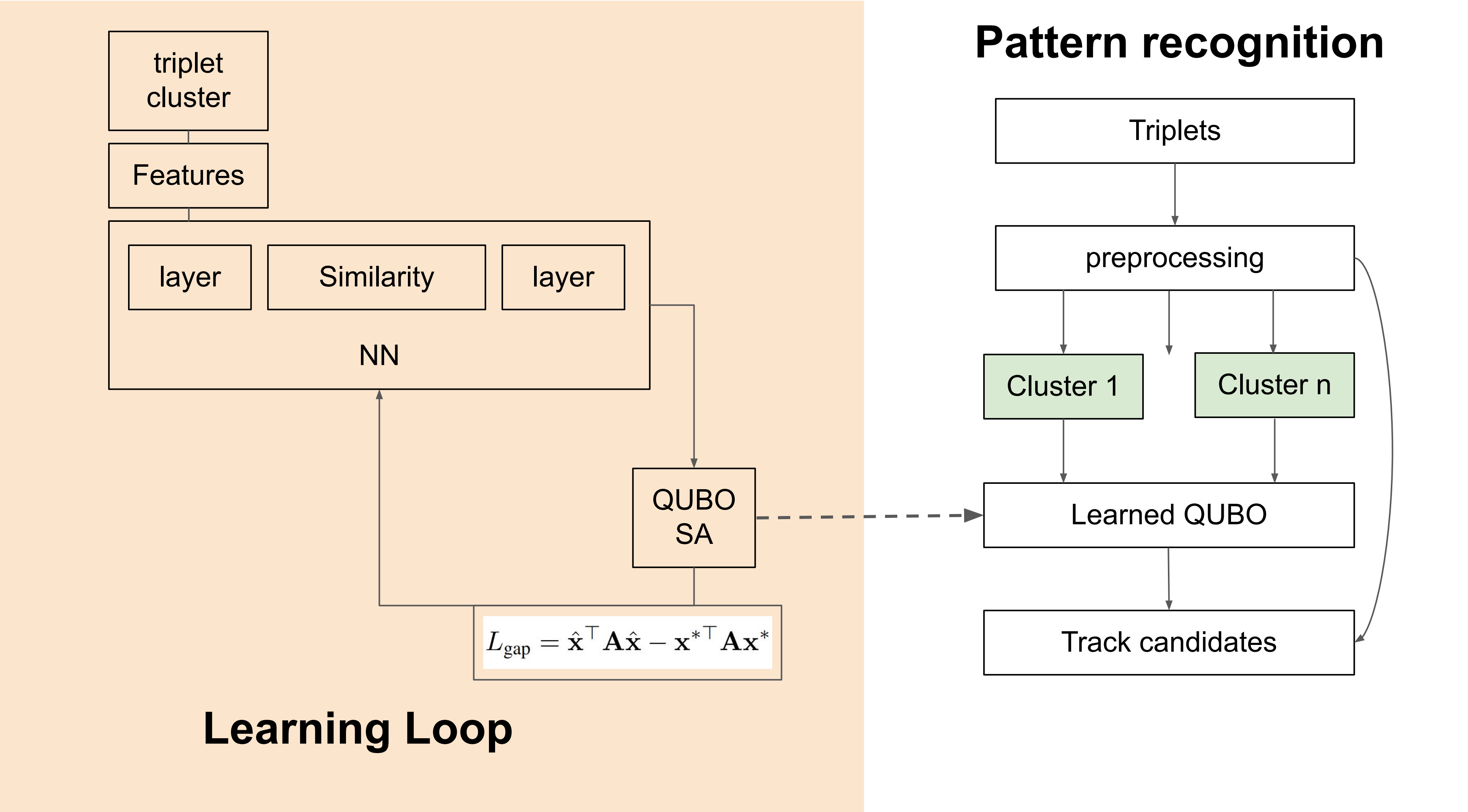
If the energy of the ground truth solution is higher than the found solution, weights are adjusted

Loss function can be adjusted to favor sparse matrices, ….

Loss function: future additions

- Favors triplets that have at least 3-same particle hits
- Favors 4-same particle hits over 3-same particle hits (?)
- Avoids conflicts

- Avoids degeneration of QUBO solutions (same energy should not lead to multiple solutions)
- Encourages sparsity (minimises number of entries)


triplet cluster
Features
layer
Similarity
layer
NN
QUBO SA
$L_{\text{gap}} = \hat{\mathbf{x}}^\top \mathbf{A} \hat{\mathbf{x}} - \mathbf{x}^{*\top} \mathbf{A} \mathbf{x}^*$
Learning Loop
Pattern recognition
Triplets
preprocessing
Cluster 1
Cluster n
Learned QUBO
Track candidates